भारतीय मानक
Indian Standard

IS 17837 : 2022

उत्प्लव, गैर अतिप्रवाही (एन.ओ.एफ.) बांध, नींव और बहिर्गम मार्गो का मृदा/मृदा-शैल बांधों के साथ संधिस्थल — दिशा निर्देश

Junction of Earth/Earth Core Rockfill Dam with Spillway, Non-Overflow (NOF) Dam, Foundation and Outlets — Guidelines

ICS 93. 010

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October 2022 **Price Group 7**

Dams and Spillways Sectional Committee, WRD 09

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Dams and Spillways Sectional Committee was approved by the Water Resources Division Council.

Most of the irrigation projects are being built with composite dams, which comprise of masonry/concrete gravity dam having central spillway with non-over flow (NOF) sections on either side. Transition between masonry/concrete dam and earth dam requires special attention and detailing during design and construction phase, as it constitutes an area of discontinuity in the material properties which needs to be handled effectively.

Over the past years, various problems related to junctions have arisen in some of the dams. Keeping the vulnerability and the importance of junction in view, it has been felt that a separate guidelines are needed for guidance in design and construction at the junction of earth dam with spillway, NOF dam and outlets. The standard has been prepared based on the wide experience gathered from field.

The Composition of the Sectional Committee responsible for the formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

JUNCTION OF EARTH/EARTH CORE ROCKFILL DAM WITH SPILLWAY, NON-OVERFLOW (NOF) DAM, FOUNDATION AND OUTLETS — GUIDELINES

1 SCOPE

This standard lays down guidelines for design of junction between earth dam/earth core rock fill dam with spillway, non-overflow (NOF) dam, foundation and outlets.

NOTE — The Standard should be read in adjunct to IS 8826.

2 REFERENCES

The Indian Standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
8826 : 1978	Guidelines for design of large earth and rock fill dams
11973 : 1986	Code of practice for treatment of rock foundations, core and abutment contacts with rock, for embankment dams
4410 (Part 15/Sec 2) : 1973	Glossary of terms relating to river valley projects: Part 15 Canal structures, Section 2 Transitions
4410 (Part 8) : 1992	Glossary of terms relating to river valley projects: Part 8 Dams and dam sections (*first revision*)
9429 : 1999	Drainage system for earth and rock fill dams — Code of practice (*first revision*)

3 TERMINOLOGY

For this standard, the following definitions shall apply.

3.1 Abutment — It is the surface at the either end of the water structure, which contacts the rock of the canyon wall.

3.2 Creep Length — Length of path of percolation/seepage of water from point of entry at upstream face to point of exit at downstream face at the contact surface of masonry/concrete and earth dam.

3.3 Creep Ratio — The ratio of creep length to the head of water to be retained.

3.4 Critical Exit Gradient (G_{EC}) — It is the exit gradient at the critical stage, when the upward seepage force acting on soil at the exit end of the structure is exactly balanced by the submerged weight of the soil. It is mathematically expressed as:

$$G_{EC} = (s - 1)(1 - n)$$

Where, 's' is the specific gravity of the soil and 'n' is its porosity.

3.5 Earthen Dam — A dam with the main section composed principally of gravel, sand, silt and clay.

3.6 Embankment — A bank of earth constructed above the natural ground surface often used as a dam to hold back water.

3.7 Erosion — The lowering and wearing of the land by weathering and transportation under the influence of energy of water.

3.8 Exit Gradient — It is the slope (or gradient) of hydraulic grade line for subsoil seepage flow, at the exit end of the structure where the seepage water comes out from subsoil.

3.9 Hydraulic Head — Hydraulic head is the elevation with respect to a standard datum at which water stands in a riser pipe or manometer connected to the point in question, in the soil. This includes elevation head, pressure head and the velocity head.

3.10 Impervious Core — A zone of impervious earth within a zoned earth or rock fill dam.

3.11 Non-Overflow Dam (NOF) — The dam portion which does not allow escape of flood water by overtopping is a non-overflow dam.

3.12 Outlet — An exit for the water from a dam/canal to another canal or channel or fields. It is a device which may be fixed or regulating.

3.13 Overflow Dam — A dam constructed with a crest to permit the overflow of water. It is also called as Spillway dam.

3.14 Percolation — Percolation is the downward movement of water through saturated or nearly saturated soil in response to the force of gravity.

3.15 Piping — When the actual exit gradient (G_E) exceeds the critical exit gradient (G_{EC}), boiling of sand starts from the exit end. Uncontrolled seepage and sand boiling leads to formation of hollow pipe like structure leading to undermining of the earth dam.

3.16 Retaining Wall — Concrete or masonry wall constructed to retain backfill or water.

3.17 Rock Fill — An embankment consisting of variable sizes of rock to provide stability and an impervious core or membrane to provide water tightness.

3.18 Scour — The action of removal of bed material from the bed of a channel/drain by the flowing water.

3.19 Transition — It is defined as a local change in cross section which produces a variation of flow from one uniform state to another [*see* IS 4410 (Part 15/Sec 2) for definition and types of hydraulic transition which is also referred as 'conversion'].

4 IMPORTANCE OF JUNCTION OF EARTH DAM

Transition between the masonry/concrete dam and earth dam requires special attention and detailing during design and construction phase, as it constitutes an area of discontinuity in the material properties. Lack of proper control and care during construction of such junction may pose problems because of different stress strain characteristics of two adjoining materials. Passage of excessive seepage water from upstream to downstream through the contact surface of masonry/concrete and earth dam at their junction, may lead to piping and in turn to induce distress condition at junction.

5 CONSIDERATIONS AT JUNCTIONS

5.1 Junctions of earthwork with foundation, abutments, masonry/concrete structures like overflow and non-overflow dams and outlets need special attention with reference to the following aspects:

a) Good bond between earthwork, masonry/concrete and foundation,
b) Adequate creep length at the contact plane at different zones,
c) Protection of earth dam slope against scouring action and slips, and
d) Easy movement of traffic over the dam.

5.2 Following factors needs to be considered while selecting a specific type of junction:

a) Height of dam and head of water to be retained,
b) Geological features of the foundation and topography at the location of junction, and
c) Cost-economics.

6 JUNCTIONS OF EARTHWORK WITH FOUNDATION, ABUTMENT, MASONRY STRUCTURES LIKE OVERFLOW AND NON-OVERFLOW DAM AND OUTLETS

6.1 Junction with Foundation

Earth dams may be founded on soil overburden or rock. For foundations on soils or non-rocky strata, vegetation like bushes, grass roots, trees etc, should be completely removed. The soil containing organic material or dissoluble salt should also be completely removed. After removal of these materials, the foundation surface should be moistened to the required extent and adequately rolled before placing embankment material. For rocky foundation, the surface should be cleaned of all loose fragments including semidetached and overhanging surface blocks of rock. Proper bond should be established between the embankment and the rock surface so prepared.

6.2 Junction with Rock Abutments

The rocky abutments should be suitably shaped and prepared in order to get good contact between the impervious core of embankment and the rock. Overhangs, if any, should be removed. Surfaces against which material is to be placed commonly should be excavated to a slope not steeper than 1(H) to 2(V). A wider impervious zone and thicker transitions are also provided at the abutment contacts to increase the length of path of seepage and to protect against erosion.

6.2.1 The bond between rocky or non-rocky abutments should be established as given in **6.1**. In addition, sufficient creep length should be provided between impervious section of the dam and abutment to provide safety against piping. The creep length should be not less than four times the hydraulic head.

6.3 Junction with Non-overflow Dam/Spillway

The junction between earth fill and concrete structure for example the wall of the spillway, can be a potential source of cracking and piping failure. To avoid this effective bond between the concrete structure and earth fill shall be established by proper compaction of contact layers.

6.3.1 The compaction of earth fill shall be carried out by above standard water content (optimum water content + 2 percent) with rubber tyre roller right up to the wall. The rolling may be carried out parallel to the wall face. In case of low plasticity earth fill (plasticity index less than 8), the same may be mixed with 2 to 5 percent of bentonite, having liquid limit of 200 to 300 to increase the plasticity and for improved bonding.

6.3.2 Side batter of 1(H):8(V) to 1(H):10(V) in vertical plane or flatter as required may be provided in the concrete face to achieve proper contact between embankment and concrete structure. The concrete surface should be left smooth, off-form concrete, not sand blasted, chipped, painted or treated.

6.3.3 The angle 'α' at which the dam axis intersects the wall may be kept 80° to increase pressure on the contact as the dam water load is applied (*see* Fig. 1). However, the angle 'α' can be increased up to 90° depending upon site conditions.

6.3.4 The downstream filters need to be widened. If the downstream filter contains significant quantity of gravel sized particles, gravels could segregate at the concrete filter interface leaving voids. In such cases, an additional filter consisting only of sand should be placed just upstream of the downstream filter (*see* Fig. 1).

6.3.5 If highly dispersive soils are being used for construction, additional consideration should be given to adding lime or any suitable material for reducing dispersivity in the vicinity of the contact with the concrete structure.

6.3.6 The settlement of the dam fill during or after construction or in an earthquake can cause a gap to form between the embankment fill and the spillway retaining wall (*see* Fig. 2). Figure 2A shows the situation where the foundation slopes away at the base of wall and Fig. 2B where there is a change of slope of the back of the wall. Both the situations should be avoided.

6.3.7 Seepage may occur along the junction of an embankment dam to a concrete gravity dam. The path length and hence the gradient varies with the reservoir level. To overcome this, wraparound portions (*see* **6.3.8**) need to be provided to arrest seepage and other safety concerns. The typical details of a potential seepage path (*PQRS*) are shown in Fig. 3.

6.3.8 The embankment wraparound for NOF blocks or upstream retaining walls (if provided) should also meet all the criterion of creep length and other safety conditions etc.

a) A filter and/or drain provided downstream of the embankment core and beneath the downstream portion of the embankment should be carried around to the downstream contact with the concrete structure. Width of impervious core needs to be increased in a smooth transition (*see* Fig. 4 for tentative arrangement of wraparound for concrete structures).

b) Compaction contiguous to walls may be improved by sloping the fill away from wall to increase roller clearances. Where rollers cannot be used because of limited clearance or where there is restriction to use the rollers near walls, power tamping of thinner layers should be used to obtain densities equal to remainder of embankment. It is desirable to place material at higher water contents to ensure more plastic material which can adjust without cracking, but then the effect of increased pore water pressures should be considered.

6.4 Junction with Outlets/Conduits

6.4.1 *Cause of Weakness Introduced at the Junction*

The placement of conduits or outlet pipes through earth dam embankments is a common cause of piping failure and accidents, particularly for small dams which do not have filters. Majority of piping failures has been attributed to the presence of conduits. The following are the most common causes of piping failure.

6.4.1.1 *Piping into the outlet/conduit*

The conduit allow erosion into the conduit if it is cracked, corroded or its joints have opened. This is most likely to occur if settlement of the conduit has occurred to compressible soil foundations.

6.4.1.2 *Piping along and above the outlet/conduit*

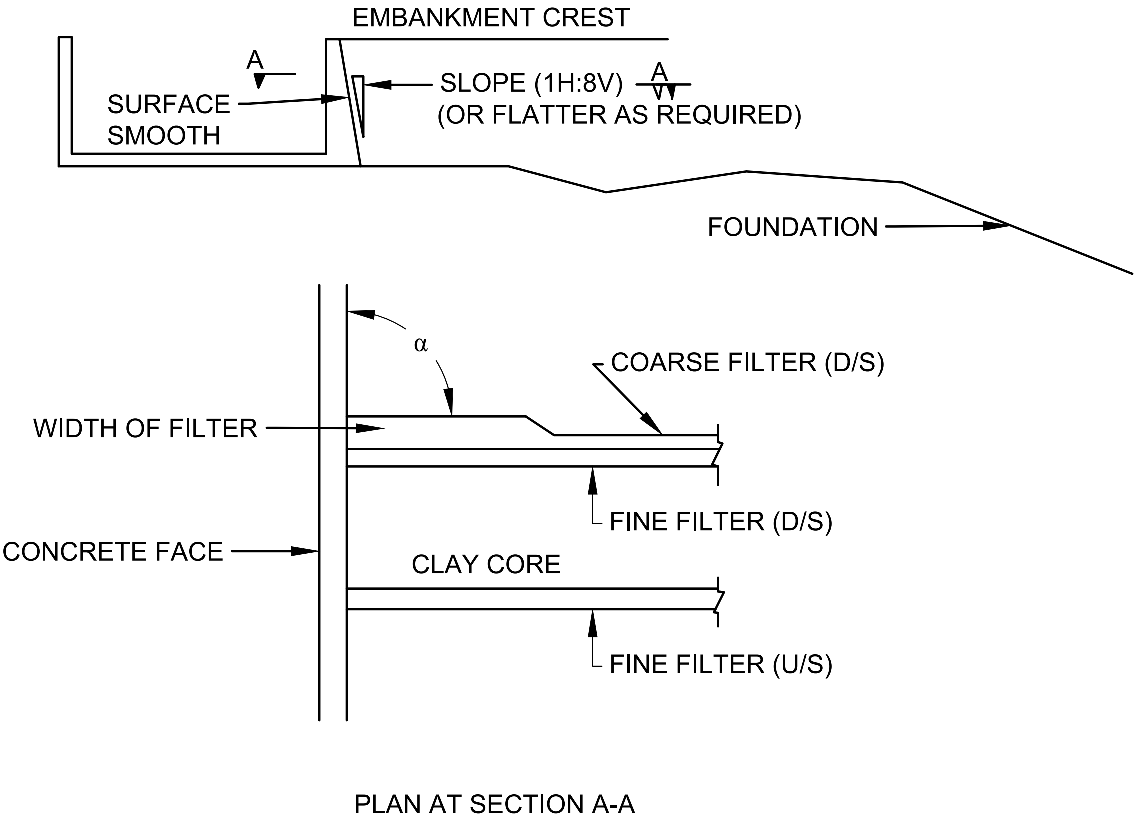
The conduit facilitates the initiation of piping by:

a) Causing stress distributions due to the stiff conduit and its surround which lead to low principal stresses and hydraulic fracture. This can occur on the sides of culverts which are constructed in a trench. It can also occur where the concrete culvert, or concrete surround around a pipe, has a sharp corner.

b) Compaction of soil is difficult, particularly when collars are provided at close intervals or concrete is covered with corrugated steel sheet or other non-smooth formworks. Compaction is also difficult where the trench provided for the conduit is narrow. Poorly compacted soil subject to collapse settlement on saturation results in forming a concentrated leak along the conduit length outside. Fig. 5 shows some of these features of failures.

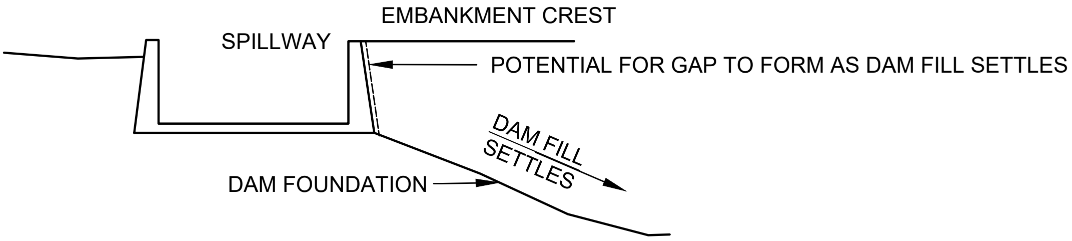
6.4.2 *Recommendations on Junction with Outlets/Conduits*

6.4.2.1 The placing of conduits through the dam, or on soil and erodible rock foundations should be avoided, by using tunnels in the abutments (for larger dams) or placing the conduit in a trench excavated into non-erodible rock and backfilled with concrete as shown in Fig. 6A. Deep, partly backfilled trenches, with steep sides as shown in Fig. 6B should be avoided as these will become zones of potentially poor compaction and low stresses conducive to hydraulic fracture and initiation of piping.

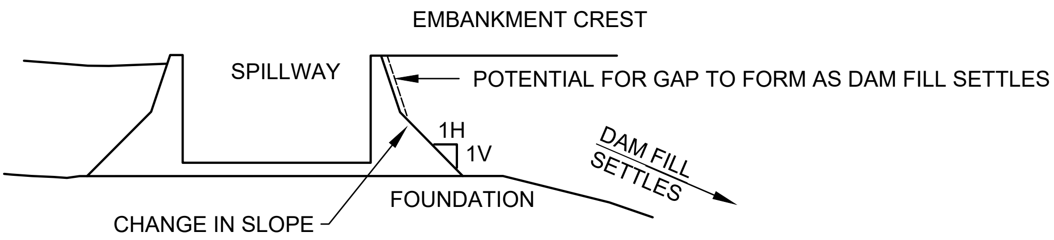


PLAN AT SECTION A-A

Fig. 1 Details of Interface Between Earthfill and Concrete Structures



(A) STEEP FOUNDATION ADJACENT TO SPILLWAY WALL



(B) CHANGE IN SLOPE OF THE RETAINING WALL

Fig. 2 Situations for Gap Between Dam Fill and Spillway Wall

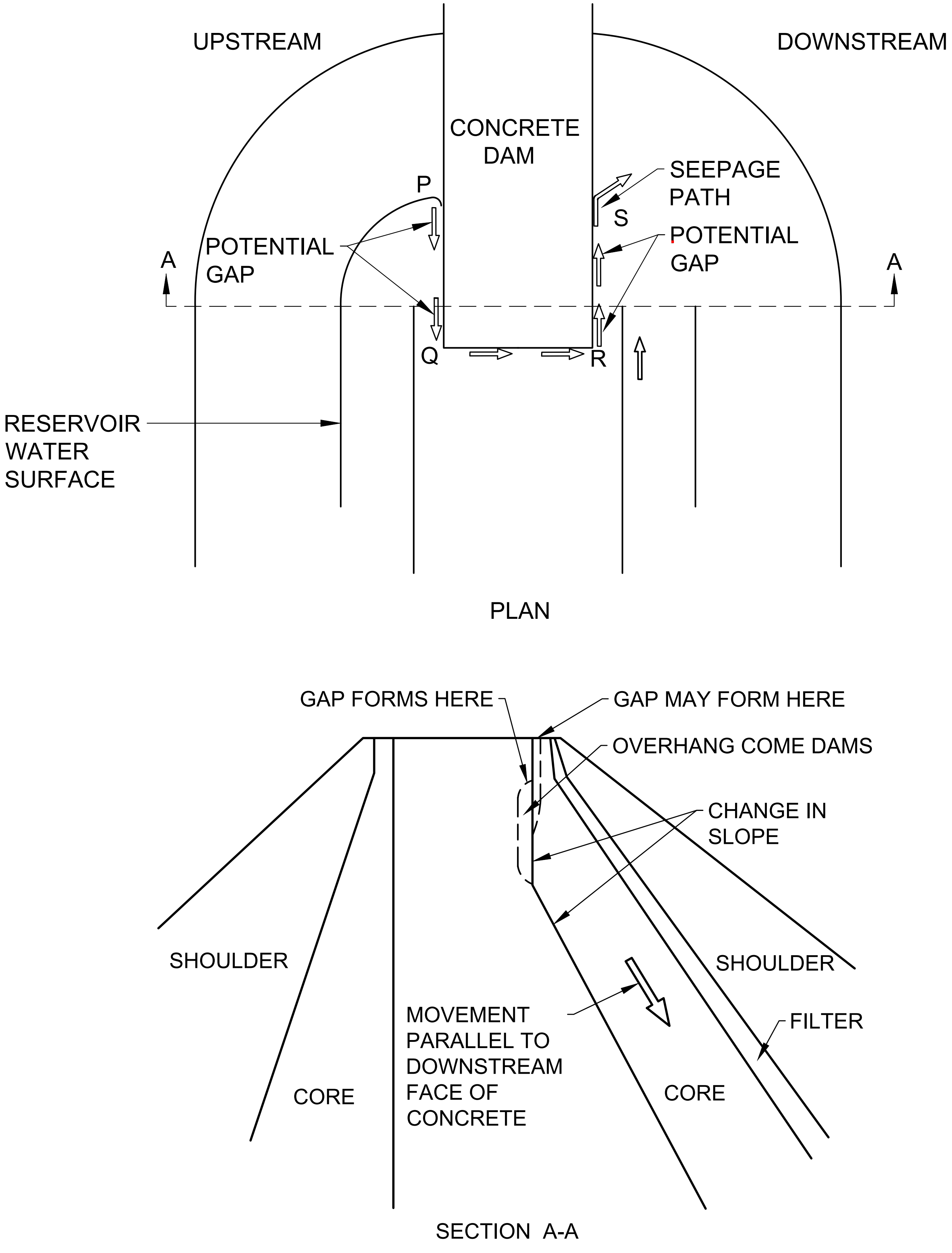


Fig. 3 Typical Details of A Potential Seepage Path (*PQRS*)

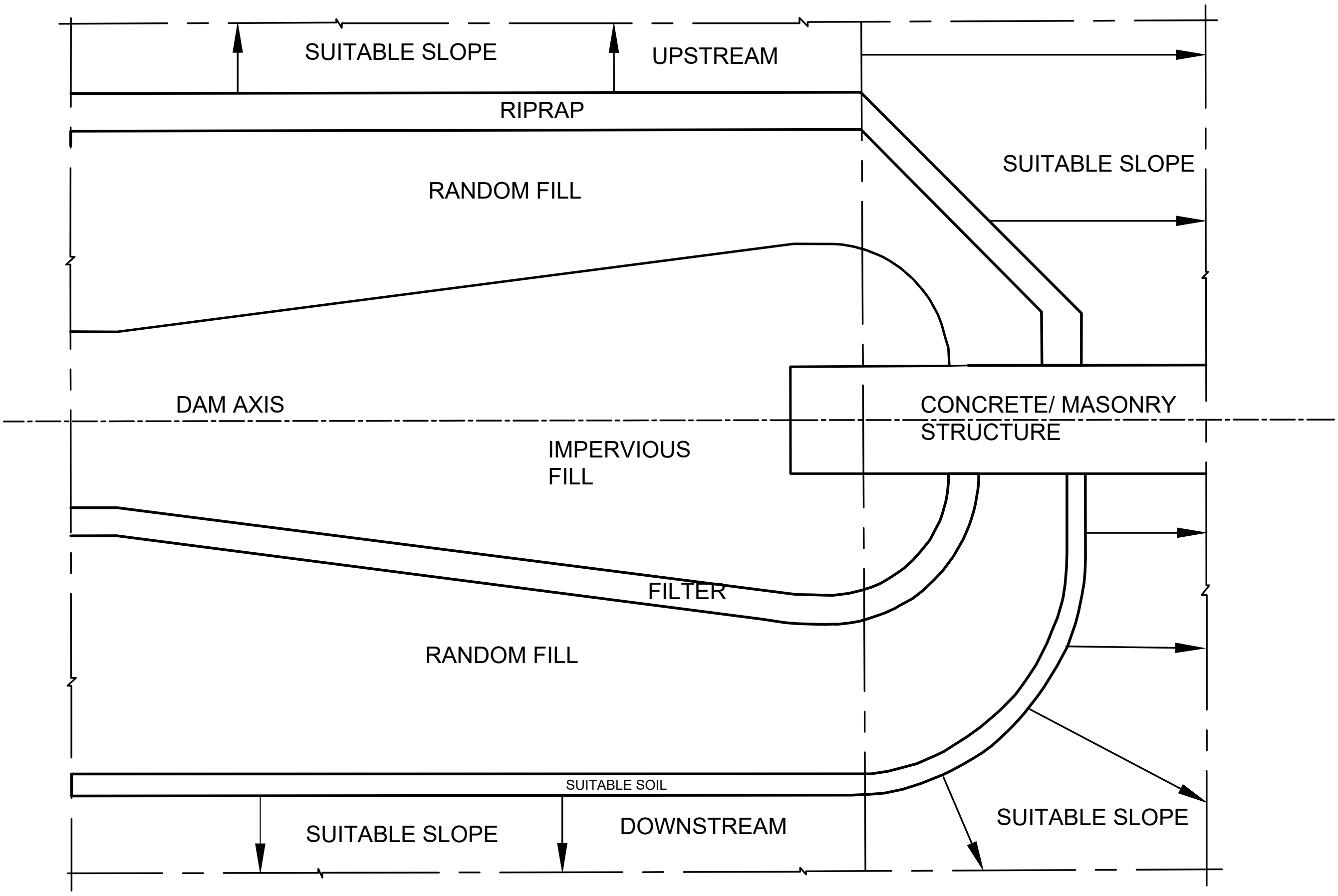
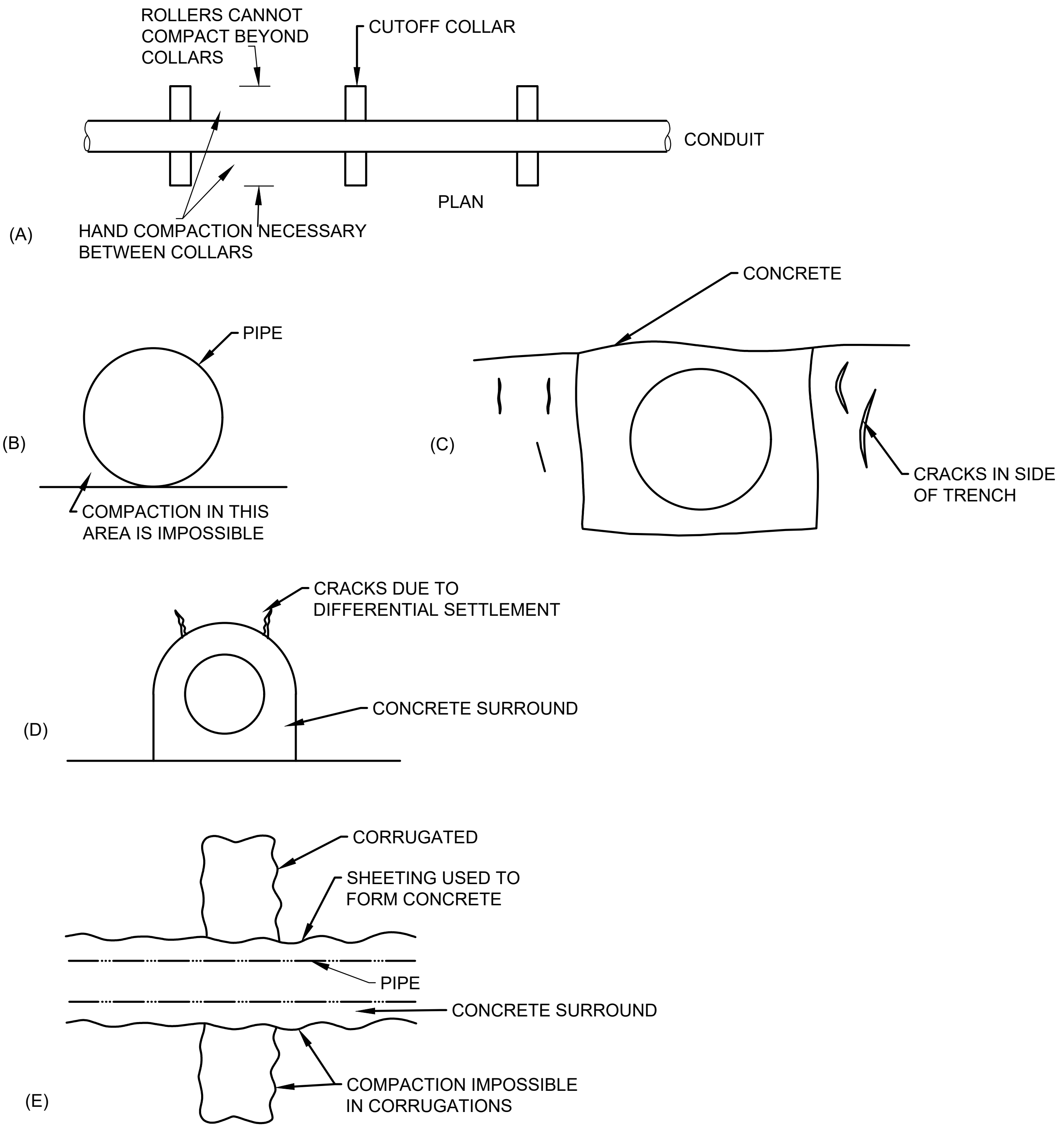


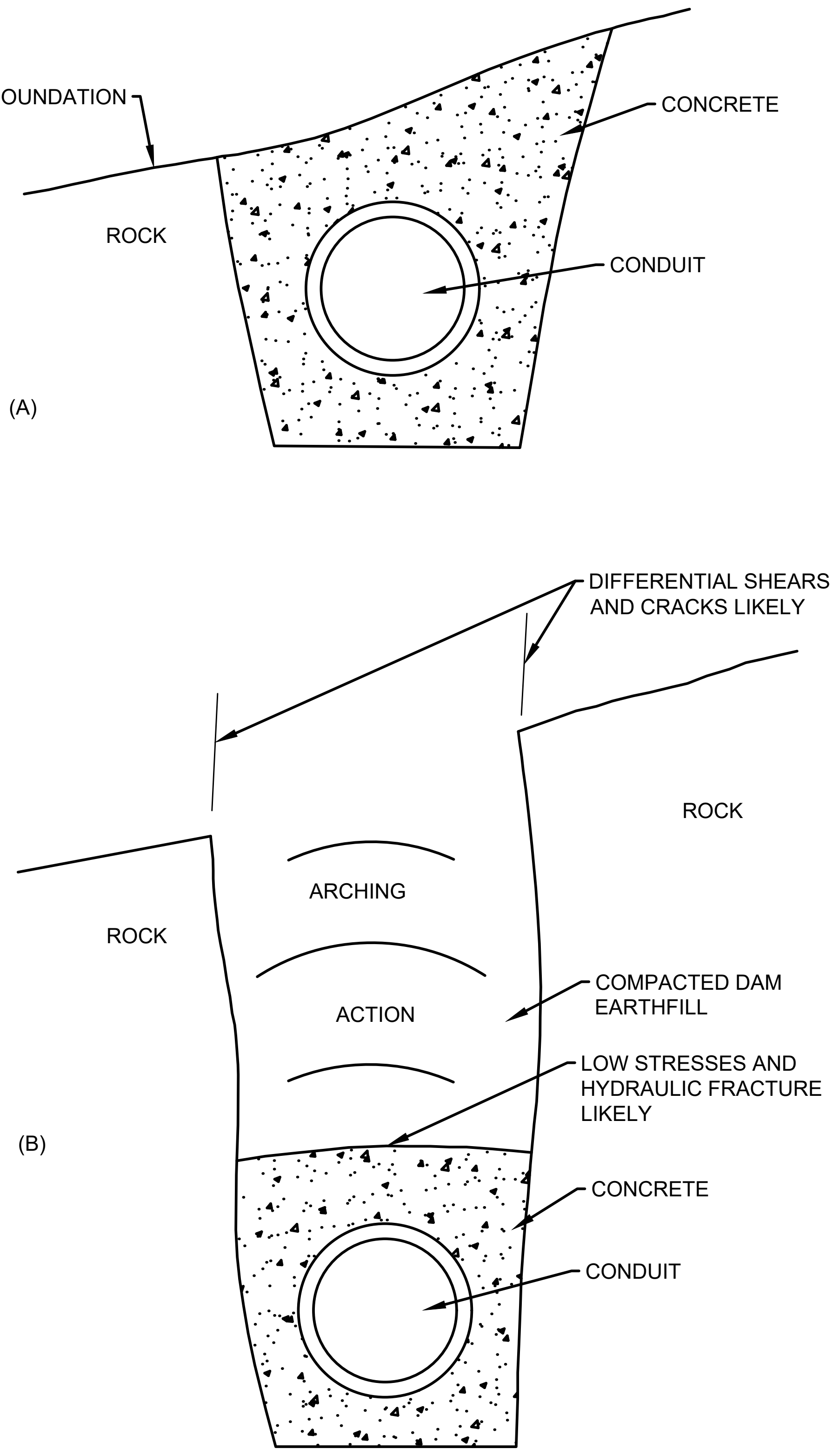
Fig. 4 Typical Illustrations for Tentative Arrangement of Wraparound for Concrete Structures


ROLLERS CANNOT COMPACT BEYOND COLLARS
CUTOFF COLLAR
CONDUIT
PLAN
(A)
HAND COMPACTION NECESSARY BETWEEN COLLARS
CONCRETE
PIPE
(B)
(C)
CRACKS IN SIDE OF TRENCH
COMPACTION IN THIS AREA IS IMPOSSIBLE
CRACKS DUE TO DIFFERENTIAL SETTLEMENT
CONCRETE SURROUND
(D)
CORRUGATED
SHEETING USED TO FORM CONCRETE
PIPE
CONCRETE SURROUND
COMPACTION IMPOSSIBLE IN CORRUGATIONS
(E)

SOME CAUSES OF PIPING FAILURE AROUND CONDUITS :

(A) INADEQUATE COMPACTION DUE TO THE PRESENCE OF CUTOFF COLLARS
(B) INADEQUATE COMPACTION UNDER PIPE
(C) CRACKING IN SOIL OR EXTREMELY WEATHERED ROCK IN THE SIDES OF A TRENCH
(D) CRACKS DUE TO DIFFERENTIAL SETTLEMENT
(E) USE OF CORRUGATIONS OR THE OTHER ROUGHENING OF THE SURFACE OF CUTOFF COLLARS OR CONCRETE SURROUND

FIG. 5 PIPING FAILURES AROUND CONDUITS



CONDUIT EMBEDDED IN ROCK FOUNDATION

(A) GOOD PRACTICE
(B) POOR PRACTICE

FIG. 6 EMBEDDED CONDUITS IN ROCK FOUNDATIONS

6.4.2.2 Where conduit has to pass through an embankment, filters should be provided in the dam and be taken around the conduit. If the foundation is soil or erodible rock, the filter should be taken locally deeper into the foundation to surround the pipe as shown in Fig. 7. The figure indicates a single diaphragm constructed around outlet conduits or other structures in the downstream section of the dam. The diaphragm consists of a graded sand-gravel that projects outward a minimum of 3 times its diameter (for pipes) except in a downward direction where differential settlement is not anticipated (that is, rock). Where other embankment or foundation drainage systems are used, the diaphragm must tie into these systems to provide a continuous zone that intercepts all areas subject to cracking, poor compaction, or other anomalies. The 'drain outlet' is a layer or layers of sand/gravel designed to act as a filter against the soil in the embankment and foundation, and with sufficient discharge capacity to transmit seepage intercepted by the filter diaphragm.

6.4.2.3 Concrete, steel or corrugated steel pipes should be continuously supported on a concrete base as shown in Fig. 8. Cut-off collars should not be provided to allow compaction adjacent to the sides of the pipe with rubber tyred rollers consistent with the strength of the pipe. The soil adjacent to the pipe should be moistened at standard water content to facilitate compaction into irregular shape of contacts and bear differential settlement without cracking.

6.4.2.4 Cast in-situ conduits should be constructed as shown in Fig. 9 with the sides sloping no steeper than 1H:8V, so that compaction equipment can be used up to the sides of pipe. The trench of the pipe should be wide enough to allow for compaction and the batter slopes should be no steeper than 1H:1V, so that arching does not develop and lead to low stresses in the trench, conducive to hydraulic fracture and cracking.

6.4.2.5 Desiccation cracking in the base and sides of any trench into which a conduit is placed should be prevented and any cracked soil should be removed immediately prior to backfilling.

6.4.2.6 Joint details should be provided in the conduit and between conduit and other structures, such as intake works, which will accommodate the likely longitudinal and vertical deformations and prevent erosion of soil into the conduit or flow of water out of the conduit.

6.4.2.7 The potential for corrosion of conduits and use of steel or corrugated steel pipes for long term operation should be considered.

6.4.2.8 Where the only earth fill available is dispersive, 2 to 3 percent (by weight) of lime should be added to the backfill soil and carefully mixed, to render it non-dispersive.

7 BONDAGE BETWEEN EARTHWORK AND MASONRY

7.1 A proper bond between earthwork and masonry is necessary to avoid any possible weak path of seepage along the line of contact of the two surfaces. To achieve these following precautions should be taken:

a) Guniting the upstream face of masonry in the portion where hearting zone overlaps the masonry or alternatively plastering the same in cement mortar (1:3) rough cast.
b) Application of mud wash to masonry faces in contact with earth at the time of and just prior to the beginning of earth work operation.
c) Placement of hearting material adjacent to the masonry on slightly wetter side (for example, optimum water content + 2 percent).
d) Compaction of impervious material in contact with masonry faces by pneumatic tampers. Heavy earth moving machinery cannot reach up to the contact planes and it is likely to damage the masonry work.

7.2 To facilitate and achieve good compaction and bond with masonry and earth dam in case of envelope type junctions, normal section of earth dam should be increased by increasing the top widths of hearting and casing zones.

7.2.1 Sometimes it is necessary to increase the width of clay core/ hearting zone in view of availability of adequate creep length. In such cases, the changed section should be transited to original section suitably and stability of the section should be checked (*see* **6.3.8** for wraparound portions).

8 PROTECTION OF EARTH DAM SLOPES AGAINST SCOURING ACTION

In order to avoid the scouring action, it is necessary to protect particularly the portions of downstream slopes of earth dam section up to tail water level on downstream side of the junction of earth dam and masonry dam. During floods, the downstream slope of earth dam in this portion shall be protected by provision of rock toe and by providing 300 mm thick hand placed riprap up to 1m above the highest tail water level.

9 OTHER DETAILS

Other details of junctions which require special considerations are:

9.1 Transition of Cut off Trench

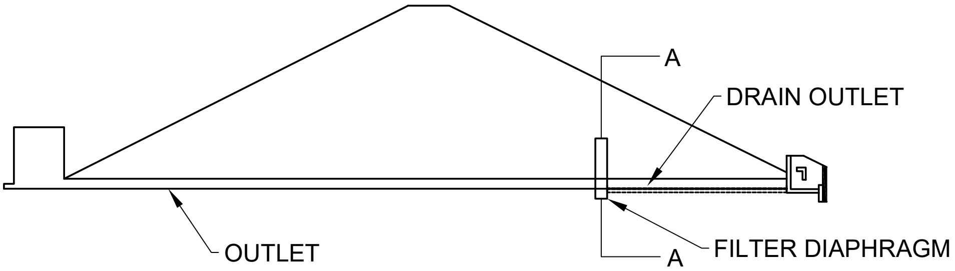
9.1.1 The centre lines of masonry dam and cut-off trench (COT) of earth dam at the point of the junction do not coincide. The profiles of the widths of the excavation of the two components of the structure at junction are therefore should be joined by a smooth transition in sufficient length with a splay of approximately 1:10.

9.1.2 Sometimes, there is difference in the bottom levels of cut off trench of earth dam and the foundation of non overflow section of the masonry dam. The transition of the two bottom levels should also be made smoothly by a gradient not steeper than 1.5(H):1(V).

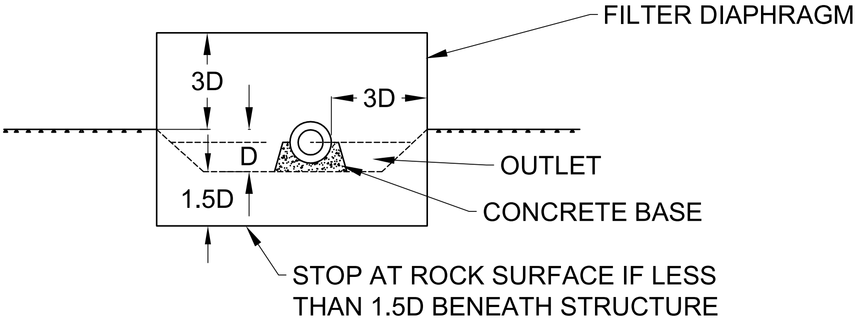
9.2 Continuation of Inclined Sand Filter

9.2.1 It is essential to continue the inclined sand filter on the downstream side of the hearting zone of earth dam section.

9.2.2 The construction of the inclined sand filter should be done strictly in accordance with the specifications laid down for the main earth dam.



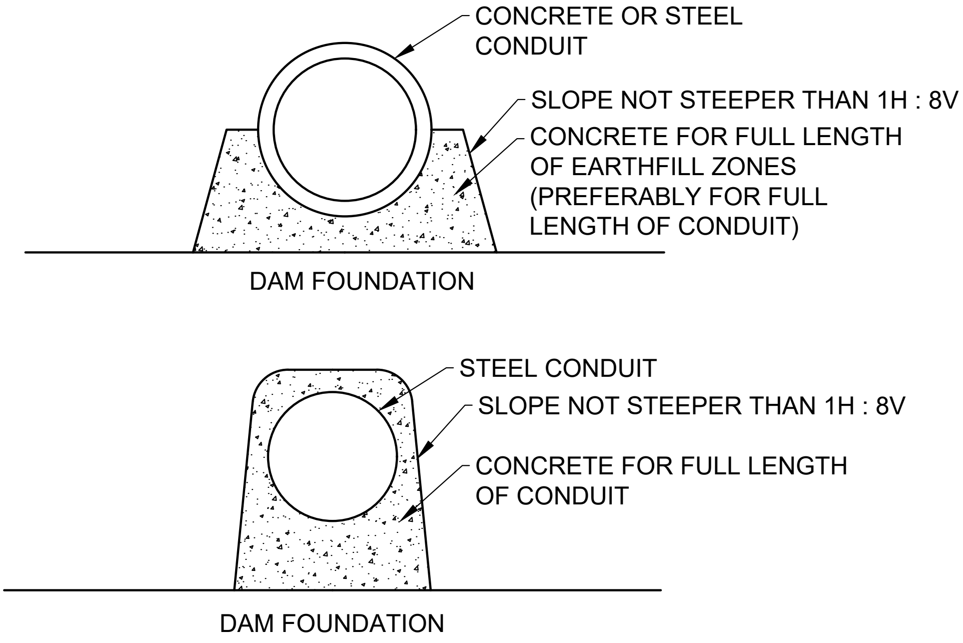
SECTION ALONG OUTLET PIPE



SECTION A-A

FILTER DIAPHRAGM FOR SEEPAGE AND PIPING CONTROL AROUND OUTLET

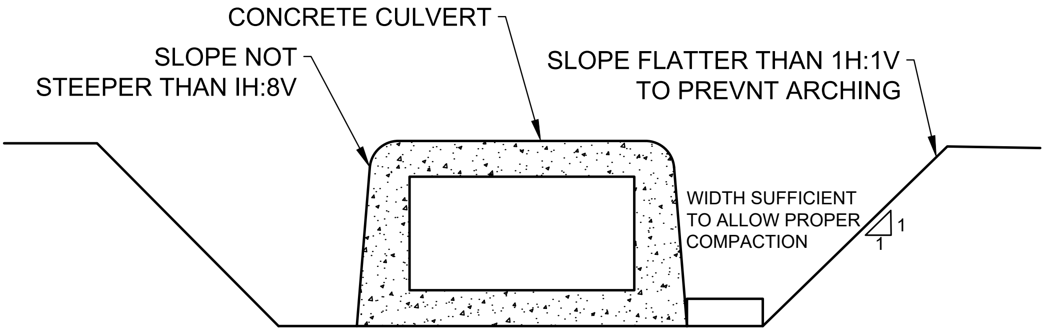
Fig. 7 Filter Diaphragm for Seepage and Piping Control Around Outlet


CONCRETE OR STEEL CONDUIT
SLOPE NOT STEEPER THAN 1H : 8V
CONCRETE FOR FULL LENGTH OF EARTHFILL ZONES (PREFERABLY FOR FULL LENGTH OF CONDUIT)
DAM FOUNDATION
STEEL CONDUIT
SLOPE NOT STEEPER THAN 1H : 8V
CONCRETE FOR FULL LENGTH OF CONDUIT
DAM FOUNDATION

CONCRETE SUPPORT FOR:

(A) CONCRETE OR STEEL CONDUIT STRONG ENOUGH TO WITH STAND EARTH PRESSURE FROM THE DAM
(B) STEEL CONDUIT REQUIRING CONCRETE SURROUND TO WITH STAND EARTH PRESSURE FROM THE DAM

Fig. 8 Concrete Support for Concrete or Steel Conduits


CONCRETE CULVERT
SLOPE NOT STEEPER THAN IH:8V
SLOPE FLATTER THAN 1H:1V TO PREVNT ARCHING
WIDTH SUFFICIENT TO ALLOW PROPER COMPACTION
1
1

TRENCH AND CULVERT DETAILS FOR CAST-IN-SITU OR PRE-CAST CONCRETE CULVERT

Fig. 9 Trench and Culvert Details for Cast in situ or Precast Concrete Culvert

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Dams and Spillways Sectional Committee, WRD 09

Organization	*Representative(s)*
Central Water Commission, New Delhi	Shri Vijai Saran (***Chairman***)
Bhakra Beas Management Board, Nangal Township	Chief Engineer Director (Bhakra Dam-Design) (*Alternate*)
Central Board of Irrigation and Power, New Delhi	Shri G. P. Patel Shri Uday Chander (*Alternate*)
Central Soil and Material Research Station, New Delhi	Dr N. P. Honkandavar Shri Mahavir Dixit (*Alternate*)
Central Water and Power Research Station, Pune	Dr M. R. Bhajantri, Sc E Dr (Shrimati) P. P. Gadge (*Alternate* I) Mrs Sangeeta R. Patnaik (*Alternate* II)
Central Water Commission, New Delhi	Director, (Cmdd NW & S), WB-II Director (Cmdd N & W) (*Alternate*)
Department of Water Resources, Govt of Punjab, Chandigarh	Shri C. S. Shergil, CE (Kad) Director Kad Admin (*Alternate*)
DMR Hydroengineering and Infrastructure Ltd, Faridabad	Shri S. C. Mittal Shri Nabakishore (*Alternate* I) Shri Shubham Bansal (*Alternate* II)
Energy Infratech Pvt Ltd	Shri Manoj Kumar Gupta Shri Pramod Chand Tiwari (*Alternate*)
Geological Survey of India, Kolkata	Dr Saibal Gosh, Director (EPE Division) Shri Imtikumzuk, SUP Geologist (*Alternate*)
Indian Institute of Technology Bombay, Mumbai	Prof V. Jothiprakash
Indian Institute of Technology Delhi, New Delhi	Head of Civil Engineering
Indian Institute of Technology Roorkee, Roorkee	Prof Deepak Khare Prof K. S. Kasiwishvanathan (*Alternate*)
Irrigation Research Institute, Roorkee	Chief Engineer Shri Naveen Singhal, Suptd. Engineer (Design) (*Alternate*)
Irrigation and Water Resources Department, Govt of Haryana	Chief Engineer/Bml Suptd. Engineer/JLN (*Alternate*)
Kerala State Electricity Board Ltd, Thiruvananthapuram	Shrimati Anni Philip Deputy CE (Designs) (*Alternate*)
Narmada and Water Resources, Water Supply and Kalpasar Department, Gandhinagar	Shri V. P. Kapadia Chief Engineer Shri H. J. Patel, Suptd. Engineer (*Alternate*)
National Institute of Rock Mechanics, Bengaluru	Dr Sripad R. Naik Shri B. H. Vijay Sekar (*Alternate*)
NHPC Ltd, Faridabad	Shri R. Musharraf Ali Khan Shri Ankur Vishwakarma (*Alternate* I) Shri Saket Kumar (*Alternate* II)
North Eastern Electric Power Corporation Limited, Guwahati	Shri S. Dhar, Deputy General Manager Shri Dipjyoti Sharma, Senior Manager (*Alternate*)

Organization	*Representative(s)*
NTPC Limited, Noida	Shri Naveen Kumar Jain Shri Prashant Narayan Gaur (*Alternate*)
SNC Lavalin Engineering India Pvt Ltd	Shri Arun Mehta Shri Janardan Baruah (*Alternate*)
THDC India Ltd, Uttarakhand	Shri Atul Jain, General Manager Dr Neeraj Agarwal, Deputy General Manager (*Alternate*)
Uttarakhand Irrigation Department, Govt of Uttarakhand, Roorkee	Chief Engineer and Director Suptd Engineer (HYD) (*Alternate*)
Water Resources Organization (PWD), Govt of Tamil Nadu, Chennai	Engineer-In-Chief, WRD and CE (G) Suptd. Engineer (Design) (*Alternate*)
Water Resources Department, Govt of Maharashtra	Suptd. Engineer (Dam Circle) Executive Engineer (Masonry Dam Division-2) (*Alternate*)
Water Resources Department, Govt of Andhra Pradesh, Vijayawada	Chief Engineer, CDO Suptd. Engineer (HYD and Flood Control) (*Alternate*)
Water Resources Department, Govt of Madhya Pradesh, Bhopal	Chief Engineer (Bodhi) Director (Dam Safety) (*Alternate*)
In Personal Capacity	Prof Nayan Sharma
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